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REGULATIONS, STANDARDS, AND GUIDES PERTAINING TO MEDICAL AND DENTAL RADIATION PROTECTION - AN ANNOTATED BIBLIOGRAPHY

David R. Snavely, et al

Bureau of Radiological Health
Rockville, Maryland

June 1969

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ENVIRONMENTAL HEALTH SERIES

Radiological Health

REGULATIONS, STANDARDS, AND GUIDES PERTAINING TO MEDICAL AND DENTAL RADIATION PROTECTION — AN ANNOTATED BIBLIOGRAPHY

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

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REGULATIONS, STANDARDS, AND GUIDES PERTAINING TO MEDICAL AND DENTAL RADIATION PROTECTION – AN ANNOTATED BIBLIOGRAPHY

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FOREWORD

For the purpose of implementing the Radiation Control for Health and Safety Act of 1968 (Public Law 90-602), a project was initiated by the Bureau of Radiological Health to gather information on existing regulations, standards, and guides pertaining to ionizing radiation protection. These recommended or regulatory standards have been developed by Federal agencies and nongovernmental organizations. Most States also have radiation protection regulations. These generally are patterned after The Council of State Governments' Suggested State Regulations for Control of Radiation, and are annotated herein. This annotated bibliography on standards pertaining to medical and dental radiation protection was prepared in a form to aid in the comparision of existing standards and for further evaluation with respect to adequacy of control and health protection from unnecessary exposure to ionizing radiation.

This is the second of a series of bibliographies prepared by the Standards Service Branch, Office of Criteria and Standards, with the cooperation of staff officers of the Bureau Divisions. The bibliography is not a complete compendium, nor are the annotations intended to be comprehensive.

The first bibliography of the series, "Regulations, Standards, and Guides for Microwaves, Ultraviolet Radiation, and Radiation from Lasers and Television Receivers – An Annotated Bibliography," contains citations of nonionizing radiation standards not included in this bibliography and may be of interest to persons working in the healing arts.

Raymond T. Moore

Raymond T. Moore, M.D.
Acting Bureau Director
Bureau of Radiological Health

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ABSTRACT

This report is an annotated bibliography of standards, regulations, and guides pertaining to medical and dental ionizing radiation protection. Included are annotations of general standards, guides and recommendations; standards on the safe operation, handling, and design of radiation equipment and sources; and standards and guides pertaining to radiation measurement.

Since the terminology for regulations, standards, and guides is not uniform among the Federal and State governments, military organizations, and nongovernmental organizations, the annotated documents are designated as Class A (established or adopted by a governmental body acting under the authority of an act, law, or statute), Class B (adopted by consensus of a committee(s) or commission(s) of technical competence in standards-setting organizations), or Class C (not adopted by a standards-setting organization, but contains information pertinent to the preparation of suitable standards or regulations).

The annotations include identification of the document, type of standard, intended complier, intended benefitter, limits and specifications, and general guidance.

Representative products and manufacturers are named for identification only, and listing does not imply endorsement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

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REGULATIONS, STANDARDS, AND GUIDES PERTAINING TO MEDICAL AND DENTAL RADIATION PROTECTION – AN ANNOTATED BIBLIOGRAPHY

INTRODUCTION

This annotated bibliography summarizes the information contained in regulations, standards, and guides promulgated by recognized standards-setting organizations and government agencies pertaining to medical and dental ionizing radiation protection. Certain documents published in foreign countries and by international organizations are also included. Several of the documents are not strictly standards for medical and dental radiation protection but are standards useful in many radiation protection programs and are included for further information.

The citations are arranged into three sections. Section I contains documents pertaining to radiation protection in general. Section II contains documents pertaining to the safe operation and design of equipment and radiation sources. Section III contains documents pertaining to the measurement of radiation.

In many cases the proper section into which a citation should be placed was not well defined. Documents were placed in the section pertaining most closely to their subject matter, but they may also contain information related to one or both of the other two sections.

The general format for annotation is:

1. Subject of document or annotated part of document.
2. Originating organization or individuals.

3. Publication identification.
4. Type of "standard."
5. Intended compliers.
6. Intended benefitters.
7. Limits and specifications.
8. General Guidance.

The type of standard is classified as either Class A, Class B, or Class C.

Class A - A standard, code, criterion, specification, rule, performance requirement, procedure, or method established or adopted by a governmental body acting under the authority of an act, law, or statute.

Class B - A standard, code, criterion, specification, rule, performance requirement, procedure, or method prepared and/or adopted by consensus of a committee(s) or commission(s) of technical competence in standards-setting organizations. These standards may be incorporated in whole or in part into a regulation. They may have restricted application depending upon the choice or obligation of individuals or users of the standard.

Class C - A guide, standard, code, criterion, specification, rule, performance requirement, procedure or method that has not yet been adopted by a standards-setting organization but contains information pertinent to the preparation of suitable standards or regulations.

Under TYPE in the annotation are entered the class, the name of the originator and a subclass, such as regulation, standard, code and specification, as defined by the originator.

The INTENDED COMPLIERS are the individuals or organizations for whom the standard was prepared as stated directly or implied in the document. The INTENDED BENEFITTERS are the individuals who are supposed to receive protection.

LIMITS AND SPECIFICATIONS include exposure limits, technical specifications, operating specifications, and other information usually expressed quantitatively. Not all

documents include all of these subcategories of limits and specifications. Quantities specified as exposure limits in the annotations clearly have biological significance. In other cases, the kinds and quantities of radiation that may exist in controlled environments are given.

GENERAL GUIDANCE includes a variety of information that is important for health protection. The particular kind varies with the subject of the document.

SECTION I. GENERAL STANDARDS, GUIDES, AND RECOMMENDATIONS

Licensing of Production and Utilization Facilities

U.S. Atomic Energy Commission (AEC)
Code of Federal Regulations, Title 10, Part 50 (January 1, 1968).

Type: Class A. AEC Regulation.

Intended Compliers: AEC licensees.

Intended Benefitters: General public.

Limits and Specifications

None.

General Guidance

Two types of licenses are provided; Class 103 licenses for commercial and industrial facilities, and Class 104 licenses for medical therapy and research and development facilities. The regulation applies to the construction, possession, transfer, utilization, and so forth, of nuclear production and utilization facilities. Sections are provided on licensing requirements and exceptions, classfication and description of licenses, application for licenses, forms, contents, ineligibility of certain applicants, standards for licenses and construction permits, issuance, and construction permits, allocation of special nuclear material, inspections, records and reports, transfer of licenses, amendment of license or construction permit at request of holder, revocation,

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suspension, modification, amendment of licenses and construction permits, emergency operations by the Atomic Energy Commission, and enforcement.

Rules of General Applicability to Licensing of Byproduct Material

U.S. Atomic Energy Commission (AEC)
Code of Federal Regulations, Title 10, Part 30 (October 1967).

Type: Class A. AEC regulations.

Intended Compliers: All persons licensed by the AEC to handle byproduct material.

Intended Benefitters: Compliers and the general public.

Limits and Specifications

Limits on the amounts of byproduct materials that may be used in certain devices and equipment are given.

General Guidance

The regulations are intended to provide control over possession and use of radioactive byproduct materials. Included are sections on exemptions, licenses, records, inspections and tests, and enforcement.

Background Material for the Development of Radiation Protection Standards

Federal Radiation Council (FRC)
FRC Staff Report No. 1 (May 1960).

Type: Class A. FRC staff report.

Intended Compliers: Federal agencies developing radiation protection standards.

Intended Benefitters: Occupational workers and the general public.

Limits and Specifications

Exposure category	Period of exposure	Maximum dose (rem)
Radiation worker:		
1. Whole body, head, trunk, active blood-forming organs, gonads, or lens of eye	Accumulated dose	5 times the number of years beyond age 18
	13 weeks	3
2. Skin of whole body and thyroid	Year	30
	13 weeks	10
3. Hands and forearms, feet and ankles	Year	75
	13 weeks	25
4. Bone	Lifetime	0.1 microgram of radium 226 or its biological equivalent
5. Other organs	Year	15
	13 weeks	5
Population:		
1. Individual	Year	0.5 (whole body)
2. Average	30 years	5 (gonads)

General Guidance

The report provides general information concerning the effects of radiation on humans, including radiation from natural and manmade sources. Information on the use of

basic guides and the preparation of radiation protection standards is included.

A Guide for the Preparation of Applications for the Possession and Use of Radioisotope Teletherapy Sources

Division of Materials Licensing, U.S. Atomic Energy Commission (AEC) (November 1965) (supersedes RC-5).

Type: Class B. A suggested guide in the preparation of applications for licenses authorizing the use of sealed scurces in teletherapy.

Intended Compliers: Organizations submitting applications to the AEC for the possession and use of therapy sources.

Intended Benefitters: Compliers.

Limits and Specifications

None.

General Guicance

The guide is intended to describe the kinds of information to be submitted in applications for the possession and use of teletherapy sources. The appendixes contain Parts 20, 30, and 35 of Title 10 of the Code of Federal Regulations, and samples of the necessary forms to be submitted with an application.

BASIC SAFETY STANDARDS FOR RADIATION PROTECTION

International Atomic Energy Agency (IAEA)
Safety Series No. 9, 1967 Ed.

Type: Class B. IAEA basic standard.

Intended Compliers: Member nations.

Intended Benefitters: Occupational workers and the general public.

Limits and Specifications

A. *Maximum Permissible Dose for Workers:*

1. Accumulated dose to the whole body, gonads, or red bone marrow shall not exceed 5(N - 18) rem where N is the individual's age in years. This is subject to a limit in any quarter of 3 rem. The accumulated dose limit is to provide flexibility when needed; otherwise the yearly limit is 5 rem/a. Special limits apply to abdominal exposure of women of reproductive age. If a worker begins radiation work at an age of less than 18 years, the dose shall not exceed 5 rem/a while his age is less than 18 years and the accumulated dose at the age of 30 shall not exceed 60 rem.

2. Dose to organs other than the gonads and red bone marrow:

Organ	Quarterly limit (rem)	Annual limit (rem)
Any single organ (excluding the gonads, red bone marrow, bone, thyroid, and skin)	8	15
Bone, thyroid, skin of the whole body (excluding the skin of the hands, forearms, feet, and ankles)	15	30
Hands, forearms, feet, and ankles	40	75

3. Planned special exposure: Dose should not exceed twice the annual dose limit in any single event, and five times this limit in a lifetime. Conditions are given under which planned special exposures should not be allowed.

B. *Dose Limits for Individual Members of the Public:*

Organ	Annual limit (rem)
Whole body, gonads, red bone marrow	0.5
Any single organ (excluding the red bone marrow, gonads, bone, thyroid, and skin)	1.5
Bone, thyroid, skin of the whole body (excluding the skin of the hands, forearms, feet, and ankles)	3
Hands, forearms, feet, and ankles	7.5

The exposure of the thyroid of children below the age of 16 shall be limited to 1.5 rem/a.

C. *Dose Limits for the Whole Population:*

The genetic dose over a period of 30 years shall be kept to a minimum and shall not exceed 5 rem.

The standard lists the maximum permissible intakes of single radionuclides in air for workers and in air and water for individual members of the public, and also the maximum permissible activity exempt from notification, registration, or licensing.

General Guidance

General guidance is given for notification, registration, and licensing. Radiation protection within establishments where radiation sources are present, administration procedures, physical surveillance programs, medical surveillance, records, and surveillance outside the establishment are discussed.

The Treatment of Radiation Injury

National Academy of Sciences - National Research Council Publication 1134 (1963).

Type: Class B. Standard.

Intended Compliers: Persons treating patients for radiation injury.

Intended Benefitters: Persons being treated for radiation injury.

Limits and Specifications

None.

General Guidance

The report is intended to aid in the treatment of peacetime cases of radiation injury. Sections are included on the acute radiation syndrome and its treatment, the assessment of injury, chemical protective agents, and decomtamination. Case histories are contained in the appendix.

Permissible Dose from External Sources of Ionizing Radiation

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 17, NBS Handbook 59 (September 24, 1954) [Addendum to HB 59 (April 15, 1958) and changed in Radiology Vol. 75 (July 1960)].

Type: Class B. NCRP recommendations.

Intended Compliers: Employers of radiation workers and radiation workers.

Intended Benefitters: Radiation workers and individuals in the vicinity of controlled areas.

Limits and Specifications

External exposure to critical organs of radiation workers.

Cumulative maximum permissible dose to the whole body, head and trunk, active blood-forming organs, gonads, and lens of the eye is 5(N - 18) rem, where N is the age in years and is greater than 18, and the dose in any 13 consecutive weeks shall not exceed 3 rem.

External exposure to other organs of radiation workers.

Maximum permissible dose to the skin of whole body is 30 rem/a, and the dose in any 13 consecutive weeks shall not exceed 10 rem. Maximum permissible dose to the hands, forearms, feet, and ankles is 75 rem/a, and the dose in any 13 consecutive weeks shall not exceed 25 rem.

Internal exposure to radiation workers.

Permissible levels from internal emitters are to be as consistent as possible with the age - proration principles. Internal dose will be limited by control of the average concentrations of radioactive materials in the air, water, or food taken into the body. Maximum permissible concentrations of radionuclides in air and water are determined from biological data when available or are calculated on the basis of an average annual dose of 15 rem for most individual organs (30 rem for the thyroid or skin). For bone seekers the maximum permissible limit is based on the distribution of the deposit, the Relative Biological Effect (RBE), and a comparison of the energy released in bone with the energy released by a maximum permissible body burden of 0.1 μg of radium 226 plus daughters.

Emergency dose (radiation workers).

An emergency or accidental dose of 25 rem to the whole body occurring once in a lifetime of the person need not be included in the determination of the radiation exposure status of the person.

Dose to persons outside of controlled areas.

The radiation or radioactive material outside a controlled area, attributable to normal operations within the controlled area, shall be such that it is improbable that any individual will receive a dose of more than 0.5 rem in any 1 year from external radiation. The maximum permissible average body burden of radionuclides in persons outside the controlled area and attributable to the operations within the controlled area shall not exceed one-tenth of that for radiation workers.

General Guidance

The report deals primarily with the protection of persons occupationally exposed to ionizing radiation from external sources and is based on presently available information on the effects of radiation exposure. For this reason, the report recommends that radiation dose be kept to a minimum. Information on radiological terminology, radiobiological considerations, protection criteria, basic permissible weekly doses for the critical organs, modifying factors in long-term exposure, noncontinuous exposure, and protection rules for long-term exposure and occasional exposure are contained in this report.

Occupational Radiation Exposure Records Systems

USA Standards Institute (USASI)

USASI N2.2 (Approved March 14, 1966). Sponsored by Atomic Industrial Forum, Inc.

Type: Class B. USASI standard practice.

Intended Compliers: Employers of persons subject to occupational radiation exposure.

Intended Benefitters: Persons subject to occupational radiation exposure.

Limits and Specifications

None.

General Guidance

The standard is intended to aid in establishing a complete and accurate record system to maintain a history of radiation exposure that will aid in the protection of an individual and the control of subsequent radiation exposure.

USA Standard Radiation Symbol

USA Standards Institute (USASI)
USASI N2.1 (March 1960).

Type: Class B. USASI standard.

Intended Compliers: All organizations possessing potential or actual sources of ionizing radiation.

Intended Benefitters: Occupational workers and the general public.

Limits and Specifications

Specifications for the proportions and color of the symbol (magenta on yellow background) are given.

General Guidance

The standard specifies the symbol to be used to identify possible or actual sources of ionizing radiation. It is not intended to be used for nonionizing radiation. Information on the design, proportion, color code, orientation, and restrictions on the use of the symbol is given. The standard does not specify levels of radiation at which the symbol is to be used.

REDUCTION OF RADIATION EXPOSURE IN NUCLEAR MEDICINE

Kenneth D. Williams, James F. Cooper, Raymond T. Moore, M.D., and Albert W. Hilberg, M.D.

Public Health Service Publication No. 999-RH-30, Proceedings of a symposium held at the Kellogg Center for Continuing Education, Michigan State University, East Lansing, Mich., August 7-9, 1967.

Type: Class C. Proceedings of a symposium.

Intended Compliers: Persons in nuclear medicine.

Intended Benefitters: Patients, physicians, occupational workers, and the general public.

Limits and Specifications

None.

General Guidance

The main objectives of the symposium were (1) to define more clearly the roles of the Atomic Energy Commission and the Public Health Service in nuclear medicine, (2) to review progress being made in certain problem areas, and (3) to

establish means for further reducing radiation exposure from diagnostic procedures while preserving or increasing the information gained.

SECTION II. SAFE OPERATION, HANDLING, AND DESIGN OF RADIATION EQUIPMENT AND SOURCES.

HUMAN USES OF BYPRODUCT MATERIAL

U.S. Atomic Energy Commission (AEC)
Code of Federal Regulations, Title 10, Part 35, and Amendments published in the Federal Register, Vol. 32, No. 200, Saturday, October 14, 1967.

Type: Class A. AEC regulations.

Intended Compliers: Persons possessing or administering byproduct materials for human uses under license from the AEC.

Intended Benefitters: Patients being administered byproduct materials and the general public.

Limits and Specifications

Limits on the amounts of various radionuclides that a physician may possess at any one time under a general license are given. The types and permissible diagnostic uses of various byproduct materials are specified.

General Guidance

The regulation governs the licensing of byproduct materials for human uses. It includes the requirements for issuance of specific licenses and general licenses and regulations governing holders of such licenses for both

possession and administration of byproduct materials for human uses.

STANDARDS FOR PROTECTION AGAINST RADIATION

U.S. Atomic Energy Commission (AEC)
Code of Federal Regulations, Title 10, Part 20 (January 1967).

Type: Class A. AEC regulations.

Intended Compliers: All persons who handle radioactive material under license of the AEC.

Intended Benefitters: Compliers and the general public.

Limits and Specifications

Limits on radiation dose are given.

General Guidance

The standard is intended to provide a control over radiation exposure arising from operations licensed by the AEC. Sections pertaining to dose levels and concentrations, precautionary procedures, waste disposal, records, reports and notification, exceptions and additional requirements, and enforcement are included in the regulations.

X-RAY APPARATUS, DENTAL, WALL MOUNTED

Department of Defense
MIL-X-36386 (DM) (February 16, 1965).

Type: Class A. Military specification.

Intended Compliers: Dental x-ray apparatus manufacturers for the military.

Intended Benefitters: Military personnel.

Limits and Specifications

Detailed specifications are given for wall-mounted dental x-ray apparatus consisting of a control unit and a separate tubearm – tubehead assembly, in which the control unit is designed to operate at least two remotely located wall-mounted tubearm – tubehead assemblies. Electrical safety specifications are taken from UL 187, "Standards for Safety – X-ray Equipment" by Underwriters' Laboratories, Inc. Radiation safety specifications are taken from NBS Handbook No. 76, "Medical X-ray Protection Up to Three Million Volts."

General Guidance

None.

Radioactive Commodities in the Department of Defense (DOD) Supply Systems.

Defense Supply Agency, Cameron Station, Alexandria, Va. 22314
DSAM 4145.8, AR 700-64, NAVSUPPUB 5012, AFM 67-8,
MCO P4400.105. (December 1967).

Type: Class A. Department of Defense regulations.

Intended Compliers: All military and civilian personnel and contractors of the Department of Defense.

Intended Benefitters: Compliers and general population.

Limits and Specifications

Reference is made to 10 CFR 20, AEC Regulations for Radiation Protection. A chart is given also for alpha and beta contamination level measurements.

General Guidance

This manual establishes the policies and procedures to be followed by Department of Defense supply installations worldwide regarding radioactive commodities. Specifically excluded from the provisions of this manual are nuclear weapons and demolition munitions, their components, and service-procured ancillary equipment.

CASSETTES, RADIOGRAPHIC FILM (MEDICAL), DIMENSIONS

U.S. General Services Administration (GSA)
Federal Standard No. 76 (May 31, 1955).

Type: Class A. GSA Federal standard.

Intended Compliers: Manufacturers of radiographic film cassettes.

Intended Benefitters: Users of radiographic film cassettes.

Limits and Specifications

Cassettes shall be of the sizes (film) and dimensions specified in table 1.

Table 1. Sizes and outside dimensions (± 1/32 inch)

Film size (inches)	Width (inches)	Length (inches)
5 by 7	6-1/8	8-1/8
6-1/2 by 8-1/2	7-5/8	9-5/8
7 by 17	8-1/8	18-1/8
8 by 10	9-1/2	11-1/8
10 by 12	11-1/8	13-1/8
11 by 14	12-1/8	15-1/8
14 by 17	15-1/8	18-1/8

General Guidance

The purpose of the standard is to establish uniform dimension for cassettes used to hold film in medical radiographic apparatus.

SCREEN, X-RAY INTENSIFYING, ROENTGENOGRAPHIC, FOR DIAGNOSTIC RADIOGRAPHY

U.S. General Service Administration (GSA)
Federal Specification GG-S-176a (September 27, 1960) and Interim Amendment - 1 (June 5, 1962).

Type: Class A. GSA Federal specification.

Intended Compliers: Manufacturers of x-ray intensifying screens.

Intended Benefitters: Medical personnel using x-ray intensifying screens, and patients.

Limits and Specifications

Intensifying screens shall be of the following types and sizes:

Type I	High-speed screens
Type II	Medium-speed (general purpose) screens
Type III	High-resolution (detail) screens

Size 1	5 by 7 inches
Size 2	6-1/2 by 8-1/2 inches
Size 3	8 by 10 inches
Size 4	10 by 12 inches
Size 5	11 by 14 inches

Size 6	14 by 17 inches
Size 7	Other, as specified

The speed factor of screens covered by this specification shall be as follows, when determined as specified in 4.4.3 of this specification:

Type I	not less than 1.6
Type II	between 1.2 and 1.4
Type III	between 0.35 and 0.50

The speed factor of screens is defined as the quotient of the speed of the film - screen combination divided by the speed of the film alone.

General Guidance

The specification applies to intensifying screens for use in diagnostic radiography. Requirements for construction material, construction, dimensions, surface properties, resistance to abrasion, speed factor, uniformity of fluorescing surface, persistence, definition, mounting material, identification marking, installation instructions, and quality of workmanship are specified. Tests for determining compliance with specification requirements are included.

X-RAY APPARATUS, RADIOGRAPHIC, MOBILE, 100 mA

U.S. General Services Administration (GSA)
Federal Specification GG-X-625 (December 14, 1955)
(Currently being revised).

Type: Class A. GSA Federal specification.

Intended Compliers: Manufacturers of mobile radiographic apparatus.

Intended Benefitters: Medical personnel operating the apparatus and patients.

Limits and Specifications

The document is essentially a specification providing all the physical requirements with which a mobile x-ray apparatus must comply to be used in the medical profession in diagnostic radiology.

The apparatus described in the standard is of one type and rated as follows:

1. 100 mA at 100 kVp on 200 to 250 volt, 60 Hz line.
2. 50 mA at 100 kVp on 100 to 125 volt, 60 Hz line.

The standard contains no limits on radiation emission or leakage.

General Guidance

The standard specifies the minimum technical requirements for a mobile radiographic unit to be used for the radiography of anatomical parts of patients in wards and locations other than the main x-ray department. Requirements for construction materials, components, and packing and marking for shipment are outlined in the standard. Sampling, inspection, and test procedures for determining compliance to the specification are also provided.

X-Ray Apparatus Set, Radiographic and Fluoroscopic, Medical

U.S. General Services Administration (GSA)
Federal Specification GG-X-635d (August 13, 1968).

Type: Class A. GSA Federal specification.

Intended Compliers: Manufacturers of radiographic and fluoroscopic x-ray apparatus sets.

Intended Benefitters: Medical personnel operating the x-ray apparatus and patients.

Limits and Specifications

The document is essentially a specification providing all the necessary requirements which an x-ray apparatus must meet in order to be used by the medical profession in diagnostic radiology. Included in these requirements are electrical, mechanical, and operational specifications for the equipment, as well as requirements for sampling, inspection and test procedures, and preparation for delivery. The specifications pertaining to radiological health are based largely upon NCRP Report No. 26, part of which has been superseded by NCRP Report No. 33.

General Guidance

The specification classifies the various types of high-tension transformers, control cabinets, tube stands, tables, body sectional devices, x-ray tubes, operating room apparatus, and cables covered by the specification. Other specifications and standards that form a part of this specification are listed.

RADIATION SAFETY IN PUBLIC HEALTH SERVICE HOSPITALS

Division of Direct Health Services Operations, U.S. Public Health Service (PHS)

PHS Manual, Chapter C-12, Environmental Health and Biomedical Engineering, Section 4 - Radiation Safety (May 1968).

Type: Class A. PHS operations manual.

Intended Compliers: Directors of PHS hospitals and medical officers in charge of PHS outpatient clinics.

Intended Benefitters: Employees and patients of PHS hospitals and outpatient clinics.

Limits and Specifications

Recommended maximum monthly dose is 0.4 rem to whole body, head and trunk, eye lens, gonads, or active blood-forming organs; 6.0 rem to hands, forearms, feet, or ankles; and 2.4 rem to skin of whole body. Maximum permissible dose limits are the same as the U.S. Atomic Energy Commission limits.

General Guidance

This section of the manual contains information on organization and administrative responsibilities for radiation safety, radiological health and safety procedures and standards, special requirements for x-ray safety, radiation safety surveys, and emergency procedures for handling radiation accidents. Samples of standard forms for reports and requests are included.

Diagnostic X-ray Protection

U.S. Departments of the Army and Air Force
Department of the Army Technical Bulletin TB MED 62, and Department of the Air Force Manual AFM 161-4, (March 23, 1964) [also Change 1, AFM 161-4 (C1) (July 10, 1967)].

Type: Class A. U.S. Army and U.S. Air Force guide.

Intended Compliers: Army and Air Force personnel using diagnostic x-ray equipment.

Intended Benefitters: Compliers and patients.

Limits and Specifications

Radiation dose limits to personnel requiring monitoring and the required monitoring devices are specified. Design specifications for x-ray rooms and specifications for shielding and filtering provisions are given. Protective aprons and gloves should have a lead equivalent of at least 0.25 mm. Beam cross-sectional areas and diameters, and target-to-skin distances are specified.

General Guidance

Guidance to persons who use diagnostic x-ray equipment and others who may have a responsibility for its safe use is provided. Operational procedures, personnel controls, and radiation surveys that will contribute to the elimination of needless x-ray exposure of personnel and patients are recommended. Criteria for the guidance of qualified personnel in the design or modification of medical x-ray installations are included.

The provisions of this publication are based on the recommendations of the National Council on Radiation Protection and Measurements Report No. 26, contained in the National Bureau of Standards Handbook 76, "Medical X-ray Protection Up to Three Million Volts."

HANDLING OF RADIUM AND RADON SEALED SOURCES FOR MEDICAL PURPOSES - SAFETY CODE

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada.
RPD-SC-3 (September 1965).

Type: Class A. Safety code.

Intended Compliers: Medical users of radium and radon sealed sources.

Intended Benefitters: Compliers and patients.

Limits and Specifications

Storage rooms must be constructed so as to ensure that the radiation fields in occupied areas and at accessible places around it do not exceed 0.25 mR/hr and 2.5 mR/hr, respectively.

Radiation levels in unrestricted wards must not be in excess of 1 mR/hr.

Patients not receiving radiation therapy and persons visiting patients may not receive a dose from ionizing radiation in excess of 300 mR in 13 weeks.

Specifications for facilities and containers are also given.

Maximum permissible dose levels given in the appendix are the same as those recommended by the ICRP.

General Guidance

This document is one of a series of Safety Codes prepared by the Radiation Protection Division of the Department of National Health and Welfare, Ottawa, Canada. These codes establish the requirements for the safe use of radioactive isotopes and ionizing radiations. They are not statutory regulations, but they define as precisely as possible the safety standards adhered to by the Radiation Protection Division in carrying out its regulatory functions.

The code provides guidance on the duties and qualifications of personnel, specifications for radium and radon sources, facilities and carrying containers, protection pro-

cedures, administrative requirements, maintenance and emergency procedures, transport by rail and road, and disposal of sources.

X Rays in Medical, Dental and Paramedical Diagnostic Radiology, Recommended Installation and Safety Procedures

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada
RPD-SC-4 (January 1968).

Type: Class A. Safety code.

Intended Compliers: Users of x-ray equipment in medical, dental, and paramedical diagnostic radiology.

Intended Benefitters: Compliers and patients.

Limits and Specifications

Radiation levels in controlled areas must be such as to ensure that no radiation worker is occupationally exposed to more than 100 mrem/week.

Radiation levels in uncontrolled areas must be such as to ensure that no person can receive more than 10 mrem/week.

Maximum permissible dose levels given in appendix I are the same as those recommended by the ICRP.

Shielding and distance requirements for x-ray equipment are also specified in the safety code.

General Guidance

This document has been prepared under the auspices of the Canadian Department of National Health and Welfare's Advisory Committee on X-ray Safety Standards. It is not a statutory regulation, but defines as precisely as possible

the safety procedures and correct installation requirements that should be followed.

The principal aims of this code are to:

1. restrict patient exposure during x-ray examinations to a minimum necessary for satisfactory diagnosis,

2. achieve effective absorption of primary and scattered radiation as near as possible to the source, and

3. provide adequate protection for persons in surrounding areas when x-ray examinations are being conducted.

Code of Practice for the Protection of Persons Against Ionizing Radiations Arising from Medical and Dental Use

Department of Education and Science, Ministry of Health, Scottish Home and Health Department, Ministry of Health and Local Government of Northern Ireland
London, Her Majesty's Stationery Office (1964).

Type: Class A. Code of practice.

Intended Compliers: All persons using radiation in medical and dental practice.

Intended Benefitters: Hospital staff, patients, and visitors.

Limits and Specifications

Exposed part of body	Maximum permissible dose for members of the hospital staff or visiting staff working with radiation		Other staff (including students not on staff)
	Persons over 18 years of age	Persons between 16 and 18 years of age	Annual dose
Whole body, blood-forming organs and gonads	Cumulative dose = 5(N - 18) rem where N is age in years 3 rem/calendar quarter	1.5 rem/a	1.5 rem
Bone, thyroid and skin of whole body	8 rem/calendar quarter 30 rem/a	3 rem/a	3 rem
Any single organ (excluding blood-forming organs, gonads, bone, thyroid and skin of whole body)	4 rem/calendar quarter 15 rem/a	1.5 rem/a	1.5 rem
Hands, forearms, feet and ankles	20 rem/calendar quarter 75 rem/a	7.5 rem/a	7.5 rem

Emergency exposure - Limit of 12 rem to the whole body, blood-forming organs, and gonads. Women of reproductive age must not be subjected to this dose.

Maximum permissible body burdens and maximum permissible concentrations (40 hour week) in air and water are given for radionuclides currently in use in hospitals.

Maximum permissible levels of contamination

Radioisotope	Contaminated area	Maximum permissible contamination ($\mu Ci/cm^2$)
Radium 226	Parts of body; personal clothing; hospital bedding; "inactive" areas	10^{-5}
All other radioisotopes	Parts of body; personal clothing; hospital bedding; "inactive" areas	10^{-4}
Radium 226	Personal protective equipment; "active" areas; glassware; tools	10^{-4}
All other radioisotopes	Personal protective equipment; "active" areas; glassware; tools	10^{-3}

Radioisotopes in use in hospitals are listed in table 1 of the document.

Levels may be averaged over an area not exceeding 100 cm^2 for parts of the body (300 cm^2 in the case of the hands); over an area not exceeding 1,000 cm^2 for floors, walls, and ceilings; and over an area not exceeding 300 cm^2 in other cases.

In close contact with a contaminated surface, a beta activity of 10^{-4} $\mu Ci/cm^2$ gives about 1 mrad/hr (delivered to soft tissue).

Specifications for diagnostic and therapeutic x-ray machines are given along with those from gamma rays, electron and neutron sealed sources and neutron generators. Maximum radioactivity for patients permitted to leave the hospital is given.

General Guidance

This code applies to all persons who are exposed to ionizing radiations arising from medical and dental practice. General measures for radiological protection are given including responsibility, suggested medical examinations, personnel

monitoring and radiation surveys. General principles of radiation protection in the use of diagnostic and therapeutic sources including x-ray machines, teletherapy machines, neutron generators, and sealed and unsealed sources are given. Policy for discharge of hospital patients treated with radioactive materials, storage and movement of radioactive material, and disposal of radioactive waste is discussed.

SUGGESTED STATE REGULATIONS FOR CONTROL OF RADIATION

The Council of State Governments
(October 1964) (currently being revised).

Type: Class B. Recommendations of the Council of State Governments.

Intended Compliers: State governments issuing regulations for the control of radiation.

(The sections of the suggested regulations pertaining to the healing arts have been largely incorporated into State regulations by at least 22 States. Eighteen other States also have radiation protection regulations in the healing arts, of which at least seven are somewhat similar to the Suggested State Regulations.)

Intended Benefitters: General public.

Limits and Specifications

Limits are provided for maximum exempt concentrations, amounts, and dose rates, maximum notification and registration periods, and generally licensed and specifically licensed quantities. Maximum permissible dose and maximum permissible concentration limits are the same as the U.S. Atomic Energy Commission limits.

General Guidance

The model regulations were prepared in cooperation with the U.S. Atomic Energy Commission and the U.S. Public Health Service and contain a comprehensive plan for the regulation of all types of radiation at the State level. The sections pertaining to radioactive materials are modeled after AEC regulations. This document would assist States desiring to regulate those radiation sources not subject to AEC regulation.

Physical Aspects of Radioisotope Brachytherapy

International Atomic Energy Agency (IAEA)
Technical Reports Series No. 75 (September 1967).

Type: Class B. IAEA report.

Intended Compliers: Medical personnel administering radioisotope brachytherapy.

Intended Benefitters: Compliers and patients.

Limits and Specifications

Patients containing less than 12 mCi of radon or 30 mCi of gold 198 may be discharged from a hospital. Embalming of cadavers may be carried out if there is less than 5 mCi of radon or 15 mCi of sealed gold 198; for cremation no special precautions are needed if there is less than 30 mCi of radon or gold 198.

General Guidance

The document is a report of a panel on Physiological Aspects of Interstitial, Intercavitary and Surface Therapy with Sealed Sources, held in Vienna on June 20-24, 1966. Guidance is provided on sources, supply, and techniques of

use; dosimetry; care and handling of sources; and personnel protection. Appendixes contain information on some physical and chemical properties of selected radioisotopes and a list of suppliers of small sealed sources and accessory equipment.

The Use of Film Badges for Personnel Monitoring

International Atomic Energy Agency (IAEA)
IAEA Safety Series No. 8 (May 1962).

Type: Class B. IAEA guide.

Intended Compliers: Organizations using film badges for personnel monitoring.

Intended Benefitters: Persons using film badges for personnel monitoring.

Limits and Specifications

None.

General Guidance

The manual presents a rather thorough treatment of the subject, including illustrations and descriptions of several types of film badges and their proper use.

Handling and Disposal of Radioactive Materials in Hospitals and Medical Research Establishments

International Commission on Radiological Protection (ICRP)
ICRP Publication 5 (1964).

Type: Class B. ICRP recommendation.

Intended Compliers: Hospitals and medical research establishments.

Intended Benefitters: Occupational workers and the general public.

Limits and Specifications

Liquid waste containing up to 10^{-4} to 10^{-5} μCi/ml of radioactive material may be discharged into sewage systems. Sealed sources having radioactivities greater than 10 μCi should not be disposed of with refuse. Waste containing up to 100 μCi of the less radiotoxic nuclides may be disposed of with ordinary waste. Radium-beryllium sources containing above 100 nCi of radium require neutron-shielding material beyond that provided for gamma radiation. Patients containing not more than about 30 mCi of phosphorus 32 or of sealed yttrium 90, or gold 198; 15 mCi of iodine 131, 10 mCi of colloidal yttrium 90, or gold 198; or 12 mCi of sealed radon 222 may be allowed to return home. No special precautions are necessary for post-mortem examinations outside treatement centers or the embalming of corpses containing not more than 5 mCi of radon 222, colloidal yttrium 90, or gold 198; 10 mCi of phosphorus 32; or 15 mCi of iodine 131, or of sealed yttrium 90, or gold 198. No special precautions are necessary in the case of cremation of corpses containing up to 30 mCi of yttrium 90, iodine 131, gold 198, or radon 222; or 10 mCi of phosphorus 32.

General Guidance

Guidance is provided on the allocation of responsibility for radiation safety measures, medical examinations of personnel, personnel monitoring, environmental monitoring, general aims and procedures for work with sealed sources and unsealed sources, and decontamination of personnel, buildings, equipment, and clothing. Information is also provided on disposal

of radioactive waste, storage and transportation of radioactive materials, discharge of hospital patients during treatment with radioactive materials, and disposal of radioactive corpses. Tables provide classification of isotopes according to relative radiotoxicity per unit of activity and classification of laboratories for handling radionuclides. Appendixes contain additional information on the handling of leakage, contamination and spills, sterilization of small sealed sources, management of radioactive wastes, and a description of an intermediate level laboratory.

Protection Against X Rays up to Energies of 3 MeV and Beta and Gamma Rays from Sealed Sources

International Commission on Radiological Protection (ICRP)
ICRP Publication 3 (1960).

Type: Class B. ICRP recommendations.

Intended Compliers: Persons using x-ray equipment or beta or gamma rays from sealed sources.

Intended Benefitters: Occupational workers, patients, and the general public.

Limits and Specifications

Specifications for filter lead-equivalent, shield lead-equivalent, focus-to-skin distance, and dose rate are given.

General Guidance

The report is intended to provide the basic requirements for radiation protection in connection with x rays and beta and gamma rays from sealed sources. Information is included

on the basic concepts of apparatus setup and operation, maximum permissible doses, and general principles regarding working conditions.

RADIOACTIVITY

International Commission on Radiological Units and Measurements ICRU Report No. 10c (NBS Handbook No. 86) (1963).

Type: Class B. ICRU report and recommendations.

Intended Compliers: Radiologists, technicians, and occupational workers.

Intended Benefitters: Compliers and general public.

Limits and Specifications

Appendixes include standards and methods of measurement of radioactivity for radiological use and radiation quantities and units.

General Guidance

Portions of this handbook discuss the direct and relative measurements of radioactivity and the availability and requirements for radioactivity standards. The parts dealing with the techniques and measurements of radioactivity in hospitals and biological laboratories are revisions of the 1959 report, embracing a review of the developments that have occurred since that report and bringing up to date the material included. In addition, a new section on low-level radioactivity in materials as related to the problems of radiological measurements has been added.

Methods of Evaluating Radiobiological Equipment and Materials

International Commission on Radiological Units and Measurements (ICRU)

ICRU Report No. 10f, NBS Handbook 89 (1962).

Type: Class B. ICRU recommendations.

Intended Compliers: Persons evaluating radiobiological equipment and materials.

Intended Benfitters: Compliers.

Limits and Specifications

Recommended parameters and conditions for the measurement of the conversion factor of x-ray image intensifiers, the measurement of the characteristics of grids, and the measurement of the characteristics of body-section radiographic equipment are specified.

General Guidance

The report deals with methods of evaluating radiological units and measurements. It includes a revision of the 1959 recommendations on the measurements of focal spots and new sections on grids, image intensifiers, and body-section equipment. An appendix contains information on radiation quantities and units.

Medical X-ray and Gamma-ray Protection for Energies up to 10 MeV – Equipment Design and Use

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 33 (February 1968).

Type: Class B. NCRP recommendation.

Intended Compliers: Medical equipment manufacturers and users (excluding dental and veterinary x-ray equipment and brachytherapy sources).

Intended Benefitters: Medical x-ray and gamma-ray equipment users and patients.

Limits and Specifications

Maximum permitted value of tube housing leakage radiation: Diagnostic, 100 mR in 1 hour at 1 meter from the source; Therapeutic below 500 kV, 1 R in 1 hour at 1 meter from the source; Therapeutic 500 kV and above, leakage radiation 1 meter from the source shall be 1 percent or less of the useful beam dose rate at 1 meter from the source. Required filtration in the primary beam of diagnostic machines: 50 kVp, 0.5 mm aluminum equivalent; 50-70 kVp, 1.5 aluminum equivalent; >70 kVp, 2.5 mm aluminum equivalent.

Many other numerical values are given such as the required accuracy of beam defining mechanisms, requirements for fluoroscopic equipment, and so forth.

General Guidance

Protection recommendations for medical x-ray equipment operating at energies up to 10 MeV and medical gamma beam therapy equipment are given. Recommendations pertaining to

equipment design, use, and operating conditions, and to radiation protection survey and personnel monitoring are covered. Structural shielding aspects of medical x- and gamma-ray installations and x-ray equipment and installations, and veterinary x-ray protection are not covered.

Medical X-ray Protection Up to Three Million Volts

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 26, NBS Handbook 76 (February 1961).

Type: Class B. NCRP recommendation.

Intended Compliers: Organizations and individuals operating medical x-ray facilities.

Intended Benefitters: Persons working with or near medical x-ray equipment.

Limits and Specifications

Specifications on shielded barrier and filter performance are given.

General Guidance

General guidance on plans for an x-ray installation, structural details of protective barriers, protection surveys, inspections, and working conditions are given. Specific rules for medical fluoroscopic, medical radiographic, mobile diagnostic, chest photofluoroscopic, and dental radiographic installations, and guidance for therapeutic x-ray installations operated at potentials up to 3 million volts and those operated at potentials of 60 kV or below

are given. Appendixes contain tables useful in x-ray protection design including use and occupancy factors and shielding requirements under different conditions. The necessary barrier thickness can also be computed by use of the maximum permissible dose, distance from target, workload, use factor, occupancy factor, and the use of given curves.

Parts of this report pertaining to equipment design and use have been superseded by NCRP Report No. 33. Portions pertaining to structural shielding will appear in NCRP Report No. 34 and portions pertaining to dental x-ray equipment and installations will appear in NCRP Report No. 35, which are expected to be published soon.

Protection Against Betatron - Synchrotron Radiations Up to 100 Million Electron Volts

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 14, NBS Handbook 55 (February 1964) (Part of this report is superseded by NBS Handbook 97).

Type: Class B. NCRP recommendations.

Intended Compliers: Manufacturers and operators of betatrons and synchrotrons.

Intended Benefitters: Persons working near betatrons or synchrotrons.

Limits and Specifications

Specifications for the construction of accelerator facilities are given.

General Guidance

This report gives guidance on electrical protection, warning and safety devices, operational precautions, first aid and fire protection, inspection and preventive maintenance, and other additional precautions. Guidance on protection against radiation hazards includes methods of measurement (x rays, electrons, and neutron flux density) and protection (materials to use as protective barriers). Guides on the structural detail and layout plans for the installations are given along with special requirements for medical, industrial, and research installations. Guidance on radiation surveys to be made includes the radiations to be measured, the characteristics of acceptable monitoring instruments, and survey procedures. Guidance on working conditions as to the person responsible for the safety of personnel, personnel monitoring, and required examinations is given. An appendix gives conversion factors, details of measuring methods, calculations and other pertinent information.

Protection Against Neutron Radiation Up to 30 Million Electron Volts

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 20, NBS Handbook 63 (November 22, 1957).

Type: Class B. NCRP recommendations.

Intended Compliers: Persons operating or using neutron sources.

Intended Benefitters: Persons working near or with neutron sources.

Limits and Specifications

Limits on maximum permissible dose are given. The report considers 12.5 rem delivered in a period of 1 month or less as the limit above which exposures shall become a problem that must be referred to recognized experts in medical radiology, radiobiology, and radiological physics.

General Guidance

A first collision dose curve and maximum permissible flux in terms of neutron energy are given. Discussed are gamma- and x-ray hazards arising from the operation of neutron sources, neutron detectors and principles in dose measurement, and radiation protection in the installation and operation of neutron sources, including polonium 210, plutonium 239, radium 226, constant voltage accelerators (Van de Graaff and Cockcroft-Walton), high-frequency accelerators (cyclotron, synchrocyclotron, betatron, synchrotron, microtron, and linear resonance accelerator), and reactors. Rules for protection against neutron radiation are discussed, which include maximum permissible dose, duties of radiation protection officers, shielding and radiation limits from sources, radiation surveys, health, and overexposure. Appendixes contain a depth dose equation for polonium – beryllium and polonium – boron sources and computed theoretical depth dose curves for a variety of neutron energies. Also included are information on flux detectors and their calibration, reactions employed in neutron production, the practical use of radiation instruments, a table of capture gamma rays, shielding calculations, and data on neutron protection near high-energy electron accelerators.

Protection Against Radiations from Sealed Gamma Sources

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 24, NBS Handbook 73 (July 1960).

Type: Class B. NCRP recommendations.

Intended Compliers: Organizations using or possessing sealed gamma sources.

Intended Benefitters: Persons working with or near sealed gamma sources.

Limits and Specifications

Specifications for shielding and leakage radiation are given.

General Guidance

The report recommends protection procedures from sealed gamma-ray sources used in both medical and nonmedical application. Transmission curves of gamma rays from various radionuclides through concrete, iron, and lead are given. Permissible transmission of radiation through a shield is calculated through use of the occupancy factor, work factor, and distance from the source. Discussed are equipment and facilities for handling, storage, and transportation of sources in the intermediate range (a few millicuries to a few curies), radiation protection surveys, personnel monitoring, and accidents entailing radiation hazards. Included under the accidents section are procedures, instruments, protective equipment, and special problems associated with radium, cobalt 60, cesium 137, iridium 192, gold 198, and

chromium 51. Appendixes contain barrier design data and computations and a discussion of encapsulation of sources with regard to source construction and testing.

Parts of this report pertaining to equipment design and use have been superseded by NCRP Report No. 33. Portions pertaining to structural shielding are expected to appear in NCRP Report No. 34 and portions pertaining to brachytherapy sources are also expected to appear in a future NCRP report.

SAFE HANDLING OF RADIOACTIVE MATERIALS

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 30, NBS Handbook 92 (March 9, 1964).

Type: Class B. NCRP recommendations.

Intended Compliers: Persons handling radioactive materials.

Intended Benefitters: Compliers and the general public.

Limits and Specifications

Specifications for air flow through hoods, glove boxes, and exhaust systems are given. Suggested levels of significant surface contamination below which an item can be released from a controlled area are given. Where large numbers of different radionuclides are involved with no knowledge of the one present in the air sample, a provisional maximum permissible concentration limit in air of 10^{-9} $\mu Ci/cm^3$ for beta emitters and 10^{-12} $\mu Ci/cm^3$ for alpha emitters may be used.

General Guidance

The recommendation contains guidance for the control and

evaluation of external and internal radiation exposure. A formula for estimating external radiation exposure, a table of specific gamma-ray constants and half-value thicknesses for various nuclides, a table on relative hazards from absorption of various radionuclides into the body, and the relationship between rad and rem for x rays, gamma rays, beta rays, fast neutrons and protons up to 10 MeV, alpha particles, and heavy recoil nuclei are provided. The recommendation contains guidance on personnel needed with regard to supervision and radiation protection. Requirements on the selection and instruction of workers, personal cleanliness, medical examination, urinalysis and other tests, and physical safeguards including shielding requirements, radioactivity containment, ventilation required (including face velocity for hoods), protective clothing and laboratory design are included.

SHIELDING FOR HIGH-ENERGY ELECTRON ACCELERATOR INSTALLATIONS

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 31, NBS Handbook 97 (July 1964).

Type: Class B. NCRP recommendations.

Intended Compliers: Organizations designing or using high-energy electron accelerator installations.

Intended Benefitters: Persons working in the vicinity of a high-energy electron accelerator.

Limits and Specifications

None.

General Guidance

The report provides presently available data required to calculate the shielding for high-energy, high-intensity electron accelerator installations. Consideration is given to the problem of shielding high-energy electron beams and the secondary x radiation, beta radiation, gamma radiation, and neutron radiation associated with such installations.

Test Methods for X-ray Equipment

National Electrical Manufacturers Association (NEMA)
NEMA Publication No. XR-3-1968 (1968).

Type: Class B. NEMA standard.

Intended Compliers: Manufacturers of diagnostic medical x-ray equipment.

Intended Benefitters: Organizations buying or using diagnostic medical x-ray equipment and patients.

Limits and Specifications

Specifications for all test conditions and procedures are given.

General Guidance

Tests specified in the standard are divided into three classes: (1) tests recommended to be conducted on one fundamental element or one system of a given type or style; (2) tests not recommended to be conducted on the customer's premises; and (3) tests recommended to be conducted on one fundamental element or one system of a given type or style and not recommended to be conducted on the customer's premises.

Test methods defined are to be used to measure the significant characteristics of equipment used in diagnostic medical x-ray systems. Using these test procedures, a complete system or functional elements of the system may be tested.

The following tests are specified: x-ray machine radiation tests; accuracy of indication, milliampere stabilization, absolute-time timer performance, and phototimer performance tests; x-ray high-voltage generator temperature, dielectric or overvoltage, short-circuit, and open-circuit tests; x-ray tube focal-spot and tube-loading tests; shockproof cable, terminal, receptacle voltage, continuity and life tests; x-ray image intensifier tube visible area, resolution, useful area, and minimum visible contrast tests; Potter-Bucky and x-ray grid pattern, cleanup, and motion tests, and body-section device performance tests.

An appendix contains minimum power supply requirements.

Standards of Performance for Film Badge Services

Donald E. Barber

Public Health Service Publication No. 999-RH-20 (September 1966).

Type: Class B. National Sanitation Foundation standard and approved Bureau of Radiological Health standard.

Intended Compliers: Companies or organizations providing film badge services.

Intended Benefitters: Organizations using film badge services.

Limits and Specifications

Control limits that constitute minimum acceptable performance for film badge services are given.

General Guidance

The standard describes techniques for measuring the accuracy of film badge services and establishes control limits that constitute minimum acceptable performance.

RECOMMENDATIONS FOR THE SAFE OPERATION OF PARTICLE ACCELERATORS

Walter W. Gundaker and Richard F. Boggs
MORP 68-2 National Center for Radiological Health, U.S. Public Health Service (February 1968).

Type: Class B. Technical Report, 2d Recommendation.

Intended Compliers: Accelerator operators, administrators, and State radiological health personnel.

Intended Benefitters: Personnel using or operating accelerators and those persons who might inadvertently be exposed to the accelerator beam or scattered radiation.

Limits and Specifications

Definitive requirements for interlock systems and warning devices for particle accelerators are given.

General Guidance

General guidance is given on the administration aspects of particle accelerator safety, accelerator controls, and radiation monitoring and surveys in the vicinity of the

accelerator. These recommendations do not include maximum permissible exposures, accelerator shielding or target handling.

Public Health Considerations in Medical Diagnostic Radiology (X rays)

Report of the Medical X-ray Advisory Committee, National Center for Radiological Health, U.S. Public Health Service (October 1967).

Type: Class B. Bureau of Radiological Health Report and Recommendations.

Intended Compliers: Medical personnel and X-ray technicians.

Intended Benefitters: Compliers and patients.

Limits and Specifications

Suggested filtration for diagnostic radiography

Operating kVp	Suggested minimum total filtration (inherent and added)
Below 50	0.5 mm aluminum equivalent
50-70	1.5 mm aluminum equivalent
Above 70	2.5 mm aluminum equivalent

The recommendations of the NCRP on maximum permissible dose (of exposure) should be consulted for detailed information.

General Guidance

This report discusses in detail all facets of medical diagnostic radiology. It illustrates the volume and usage

of diagnostic x rays in the United States and the role of the Public Health Service in this field. Medical x-ray equipment and installations are reviewed in detail and appropriate recommendations are made for each portion of x-ray equipment.

X-RAY EQUIPMENT

Underwriters' Laboratories, Inc. (UL)
X-ray Equipment, UL 187, 2d Ed. (November 1957).

Type: Class B. Underwriters' Laboratories standard.

Intended Compliers: Manufacturers whose x-ray equipment is listed by Underwriters' Laboratories.

Intended Benefitters: Persons or organizations using the listed x-ray equipment.

Limits and Specifications

Specifications for switches used on medical radiographic, fluoroscopic, and therapy equipment, and industrial radiographic and fluoroscopic equipment are given. Required markings on the x-ray equipment are specified including a suitable warning statement concerning the hazard from x radiation.

General Guidance

It is stated that x-ray equipment,whose intended use is such that it will be under the control of an operator not familiar with the hazard from x radiation, shall be investigated with respect to protection or shielding incorporated in the equipment.

Classification of Sealed Radioactive Sources

USA Standards Institute (USASI)
USASI N5.10 (April 22, 1968).

Type: Class B. USASI standard.

Intended Compliers: Manufacturers of sealed radioactive sources.

Intended Benefitters: Users of sealed radioactive sources.

Limits and Specifications

Tables contain specifications on relative radiotoxicity, radioactivity level, performance requirements for typical usage, and classification of sealed source performance standards. The procedure for establishing classification and performance standards, and the methods of classification, designation, and identification are specified. Test procedures, test conditions, test cycle durations, and test equipment specifications are also given.

General Guidance

The standard establishes the classification of sealed sources for particular usages based on radiotoxicity, curie content, and performance requirements. It is intended to promote uniformity of performance for sealed sources and assure containment of the radioactive material in the source, but does not attempt to establish design features.

Testing procedures for demonstrating performance under temperature, external pressure, impact, vibration, and puncture conditions are given. Evaluation of test performance is accomplished through visual examination and performance of a leak test. Also contained in the appendixes is information on a quality control program.

Dimensions for Medical X-ray Sheet Film (Inch and Centimeter Sizes)

USA Standards Institute (USASI)
USASI PH1.17 (1956, reaffirmed 1962).

Type: Class B. USASI standard.

Intended Compliers: Medical x-ray sheet film manufacturers.

Intended Benefitters: Organizations using medical x-ray sheet film.

Limits and Specifications

The standard provides tolerances on dimensions and squareness for the cutting of medical x-ray sheet film.

General Guidance

None.

Evaluating Films for Monitoring X Rays and Gamma Rays Having Energies Up to 3 Million Electron Volts

USA Standards Institute (USASI)
USASI PH2.10 (July 1965).

Type: Class B. USASI standard method.

Intended Compliers: Manufacturers and testers of film used for monitoring x rays and gamma rays.

Limits and Specifications

Specifications on the methods and processes to be used for evaluating films are given.

General Guidance

The standard provides methods for determining reproducible reference exposures that are intended to assist the user in determining the useful range of film for radiation monitoring. Sensitometric procedures are described for films exposed to x rays and gamma rays of specified energy distributions. Recommended sensitometric procedures are also given for combinations of films and absorbers or intensifying screens where these arrangements are used for radiation monitoring.

Guide to the Design of a Radioisotope Laboratory (Type B)

USA Standards Institute (USASI)
USASI N5.2 (November 12, 1963).

Type: Class B. USASI standard.

Intended Compliers: Persons designing a radioisotope laboratory.

Intended Benefitters: Occupational workers.

Limits and Specifications

Specifications are provided for laboratory work area construction, floor space, lighting, air temperature and humidity, air-exhaust system capacities and sizes, hood construction, fire extinguisher equipment, glove box and port

construction, safety shower installations, viewer panel dimensions, and counting-room air temperature and humidity.

General Guidance

The standard recommends the essential features of a laboratory in which radionuclides are used and identifies the general requirements for the categories of radioisotope laboratories defined in the standard. The amounts and kinds of isotopes that can be safely handled in laboratories of various designs have been categorized. Five appendixes (not a part of the standard) give information on shielding, high-efficiency air filters, specifications for metal wall finishes, hood designs, and an example of a glove box.

Sensitometry of Medical X-ray Films

USA Standards Institute (USASI)
USASI PH2.9 (December 1964).

Type: Class B. USASI standard method.

Intended Compliers: Manufacturers of medical x-ray films.

Intended Benefitters: Organizations and persons using medical x-ray films.

Limits and Specifications

Specifications for the methods to be used in determining film characteristics are given.

General Guidance

The standard provides methods for determining the speed and contrast characteristics of films used in medical roent-

genography. Sensitometric procedures are described for films exposed directly to x rays, films exposed with intensifying screens, and films used in photofluorography. "Speed" and "average gradient" of such films are defined.

PRELIMINARY REPORT ON RADIOGRAPHIC HOLDING, PARALLELING, AND SHIELDING DEVICES

Council on Dental Materials and Devices, Americal Dental Association

J Amer Dental Assoc 77:4:884-887 (October 1968).

Type: Class C. Proposed radiographic holding, shielding, and paralleling devices for dental x-ray machines.

Intended Compliers: Dentists.

Intended Benefitters: Dentists and patients.

Limits and Specifications

The report primarily describes how the various devices operate; however, it does point out a few specifications of some of the devices.

General Guidance

This report presents the principles on which the various radiographic holding, paralleling, and shielding devices are based. It discusses the advantages and disadvantages of the numerous devices; however, it is not an endorsement of any one piece of equipment.

"These devices eliminate the need for a patient to hold the film packet in his mouth during an exposure. A few of these devices have additional collimating and shielding features beyond those that are built into some x-ray machines.

"Some of the devices discussed in this report were designed for experimental purposes and are not available commercially. Statements of effectiveness and clinical feasibility of the devices are based primarily on claims of manufacturers or the investigators concerned. To date, no evaluations have been conducted by the Council on Dental Materials and Devices of the American Dental Association."

RADIATION HYGIENE AND PRACTICE IN DENTISTRY I

Council on Dental Research and Council on Dental Materials and Devices, American Dental Association
J Amer Dental Assoc 74:1032-1033 (April 1967).

Type: Class C. Report.

Intended Compliers: Dentists.

Intended Benefitters: Patients and office personnel.

Limits and Specifications

None.

General Guidance

This report discusses the protection of the patient including recommendations as to frequency of radiographic examination, and the use of protective coverings.

RADIATION HYGIENE AND PRACTICE IN DENTISTRY II

Council on Dental Research and Council on Dental Materials and Devices, American Dental Association
J Amer Dental Assoc 75:1197-1198 (November 1967).

Type: Class C. Report.

Intended Compliers: Dentists.

Intended Benefitters: Dental office personnel.

Limits and Specifications

None.

General Guidance

Discussed are safeguards for protecting office personnel during dental radiography including proper shielding, the use of radiation barriers and monitoring services and the proper operating procedures.

Radiation Hygiene and Practice in Dentistry III

Council on Dental Research and Council on Dental Materials and Devices, American Dental Association
J Amer Dental Assoc 76:115-116 (January 1968).

Type: Class C. Report.

Intended Compliers: Dentists.

Intended Benefitters: Patients and office personnel.

Limits and Specifications

None.

General Guidance

Discussed are guidelines for minimizing radiation exposure through the use of modern radiological equipment and

techniques involving collimation or restriction of the useful beam, filtration, high-speed film, and other pertinent factors.

RADIATION HYGIENE AND PRACTICE IN DENTISTRY IV

Council on Dental Research and Council on Dental Materials and Devices, American Dental Association
J Amer Dental Assoc 76:363-364 (February 1968).

Type: Class C. Report.

Intended Compliers: Dentists.

Intended Benefitters: Patients.

Limits and Specifications

Only those films listed in Speed Group D as designated in "American Standard Speed Classification for Intraoral Dental Radiographic Film: Diagnostic Grade, PH 6.1 - 1961" should be used.

General Guidance

Times are discussed in relation to fast-speed film.

RADIATION HYGIENE AND PRACTICE IN DENTISTRY V

Council on Dental Research and Council on Dental Materials and Devices, American Dental Association
J Amer Dental Assoc 76:602-602 (March 1968).

Type: Class C. Report.

Intended Compliers: Dentists.

Intended Benefitters: Patients and dental office personnel.

Limits and Specifications

Sets forth some specifications for processing and developing x-ray film.

General Guidance

Discusses visualization factors, including darkroom procedures and illumination techniques.

Medical Uses of Radium and Radium Substitutes

National Advisory Committee on Radiation, U.S. Public Health Service (PHS)
Public Health Service Publication No. 999-RH-16 (July 1965).

Type: Class C. Report.

Intended Compliers: Organizations using radium or radium substitutes for medical purposes.

Intended Benefitters: Persons using radium or radium substitutes for medical purposes, or patients being treated with radium or radium substitutes.

Limits and Specifications

None.

General Guidance

This document is a report on the Conference on Medical Uses of Radium and Radium Substitutes held at The Center for Continuing Education, University of Chicago, September 3-4, 1964.

The conclusions reached by the Conference and outlined in the report indicate a need for comprehensive regulatory programs for radium, sealed source design standards for radium, adoption of suitable radium substitutes, research efforts toward developing better and safer sealed sources, and promotion of therapeutic techniques that will reduce radiation exposure to medical personnel.

PHYSICAL SURVEY MANUAL, DENTAL X-RAY

Medical and Occupational Radiation Program, National Center for Radiological Health
Public Health Service Publication No. 1559 (April 1967).

Type: Class C. PHS Guide.

Intended Compliers: Health agencies.

Intended Benefitters: Compliers.

Limits and Specifications

None.

General Guidance

This manual sets forth a standard physical radiation protection survey method. An illustrated step-by-step description of an office inspection visit based upon the use of PHS Form 3657 and an appendix of reference material related to dental radiological health is given.

Radioisotope Facilities in the General Hospital

Samuel C. Ingraham II, Mark Barnett, and Wilbur R. Taylor
Public Health Service Publication No. 930-D-22 (January 1966).

Type: Class C. PHS basic guideline.

Intended Compliers: Architects, planners, and administrators who plan isotope installations in general hospitals of small or moderate size in which elaborate research and teaching programs involving radioisotopes are not anticipated.

Intended Benefitters: Compliers.

Limits and Specifications

Two suggested room plans for a radioisotope facility are given. Position of cabinets, equipment, and so forth is given along with room dimensions.

General Guidance

Discussed in general terms are radiation hazards, location of radioisotopes and inpatients, radioisotope procedures, and other considerations, such as electrical heating and ventilation, seating, work surfaces, storage cabinets, and plumbing.

SECTION III. RADIATION MEASUREMENT STANDARDS AND GUIDES

CLINICAL DOSIMETRY

International Commission on Radiological Units and Measurements (ICRU)
ICRU Report No. 10d, NBS Handbook 87 (1962).

Type: Class B. ICRU recommendations.

Intended Compliers: Physicists and clinicians engaged in radiotherapy.

Intended Benefitters: Radiotherapy patients.

Limits and Specifications

None.

General Guidance

Much of the Commission's work on clinical dosimetry is brought together in this Handbook. Included is an extensive discussion of practical calibration procedures and the determination of dose along the central ray. Depth dose data relative to stationary and moving-field therapy have been extended as have the conversion data necessary to relate ionization measurements to absorbed dose. The principal effort has been toward the definition of nomenclature and the indication of methods. While some examples are given and data are provided for these, in general, the reader

is referred to other published data. The report considers ways of increasing the accuracy and comparability in clinical dosimetry. The discussion includes not only the physical aspects of dose measurement but also the wider subject of planning treatment in such a way as to deliver the prescribed absorbed dose to a defined "target volume." It also includes comments on the sources of error in clinical dosimetry and discusses the information which should be reported about any new treatment technique. Appendixes include pertinent material taken from other reports in this series.

Radiobiological Dosimetry

International Commission on Radiological Units and Measurements (ICRU)

ICRU Report No. 10e, NBS Handbook 88 (1962).

Type: Class B. ICRU recommendations.

Intended Compliers: Experimental radiologists.

Intended Benefitters: Compliers.

Limits and Specifications

None.

General Guidance

The report deals primarily with radiobiological dosimetry, and considers methods of improving the accuracy and intercomparability of absorbed dose measurements in radiobiology. It is a handbook for the experimental radiobiologist. It emphasizes the great importance of planning the experimental work in a way which makes the dosimetry easier

and more accurate, and it illustrates how this can be done. An appendix contains information on radiation quantities and units.

Photographic Dosimetry of X and Gamma Rays

National Bureau of Standards (NBS)
National Bureau of Standards Handbook 57 (February 1954).

Type: Class B. NBS Handbook.

Intended Compliers: Organizations using photographic film for the measurement of radiation dose.

Intended Benefitters: Compliers.

Limits and Specifications

None.

General Guidance

The handbook contains basic information necessary for photographic dosimetry of x and gamma rays. It contains information accumulated in the Radiation Physics Laboratory of the National Bureau of Standards that could be useful to other workers in the field of x- and gamma-ray dosimetry. The main emphasis of the handbook is on the properties of photographic emulsions that make their use for radiation dosimetry possible and the selection of processing methods of the film material.

Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 25, NBS Handbook 75 (February 1961).

Type: Class B. NCRP recommendations.

Intended Compliers: Persons measuring the absorbed dose of neutrons or mixtures of neutrons and gamma rays.

Intended Benefitters: Compliers.

Limits and Specifications

None.

General Guidance

Discussed are the interactions of radiation with matter and the general methods of radiation dosimetry. Specific instruments and devices for the determination of dose are discussed and their advantages and disadvantages given. Included are tissue-equivalent ionization chambers, paired chambers, proportional counters, photographic film, Fricke and ceric sulfate dosimeters, gamma-ray and neutron spectrometers, threshhold detectors, Hornyak button, and paraffin moderated boron trifluoride counters. A table summarizes different types of ionization chambers with regard to type of radiation measured, energy range covered, dose range covered, and their application. Also discussed is the special problem of measuring the dose from relativistic neutrons. The appendix gives the first collision dose versus energy for both protons and neutrons for various materials.

Measurement of Neutron Flux and Spectra for Physical and Biological Applications

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 23, NBS Handbook 72 (July 15, 1960).

Type: Class B. NCRP recommendations.

Intended Compliers: Persons measuring neutron flux and spectra for physical and biological applications.

Intended Benefitters: Compliers.

Limits and Specifications

None.

General Guidance

The measurement of neutron flux and spectra is discussed, various methods are compared, and results of intercomparisons are given. Methods of measurement are discussed for the emission rate of radioactive neutron sources, thermal neutron flux, intermediate neutron flux, fast neutron flux, and neutron energy spectra. Neutron radiation instruments for area survey and personnel monitoring involving flux and spectrum measurements are included. Typical spectra of various neutron sources are shown.

Radiological Monitoring Methods and Instruments

National Council on Radiation Protection and Measurements (NCRP)

NCRP Report No. 10, NBS Handbook 51 (April 7, 1952).

Type: Class B. NCRP recommendations.

Intended Compliers: Users of radioactive materials and other sources of radiation.

Intended Benefitters: Persons working with or near sources of radiation.

Limits and Specifications

Specifications for instrument accuracy, sensitivity, and detector window thickness are given. The introduction contains the maximum permissible radiation exposures to man recommended by the NCRP as of January 8, 1957.

General Guidance

The general principles of radiation hazard control are discussed. Criteria for alpha-particle, beta-particle, gamma-ray, and neutron detectors, and for alpha-particle, beta-particle, and gamma-ray measuring instruments are given. Also listed are radiation survey methods and precautions with respect to radioactive isotopes, and medical and industrial installations (includes television receivers, electronic tubes, x-ray diffraction units, electron microscopes, and so forth). General guides on air-sampling equipment and methods, analysis of water samples, and alpha- and beta-particle counting are given along with proton ranges in paraffin, range of beta particles in aluminum, and buildup and decay of radon daughters.

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REGULATIONS, STANDARDS, AND GUIDES PERTAINING TO MEDICAL AND DENTAL RADIATION PROTECTION--AN ANNOTATED BIBLIOGRAPHY

ABSTRACT

This report is an annotated bibliography of standards, regulations, and guides pertaining to medical and dental ionizing radiation protection. Included are annotations of general standards, guides and recommendations; standards on the safe operation, handling, and design of radiation equipment and sources; and standards and guides pertaining to radiation measurement.

Since the terminology for regulations, standards, and guides is not uniform among the Federal and State governments, military organizations, and nongovernmental organizations, the annotated documents are designated as Class A (established or adopted by a governmental body acting under the authority of an act, law, or statute), Class B (adopted by consensus of a committee(s) or commission(s) of technical competence in standards-setting organizations), or Class C (not adopted by a standards-setting organization, but contains information pertinent to the preparation of suitable standards or regulations).

The annotations include identification of the document, type of standard, intended complier, intended benefitter, limits and specifications, and general guidance.

THE ABSTRACT CARDS accompanying this report are designed to facilitate information retrieval. They provide space for an accession number (to be filled in by the user), suggested keywords, bibliographic information, and an abstract. The keyword concept of reference material filing is readily adaptable to a variety of filing systems ranging from manual - visual to electronic data processing. The cards are furnished in triplicate to allow for flexibility in their use.